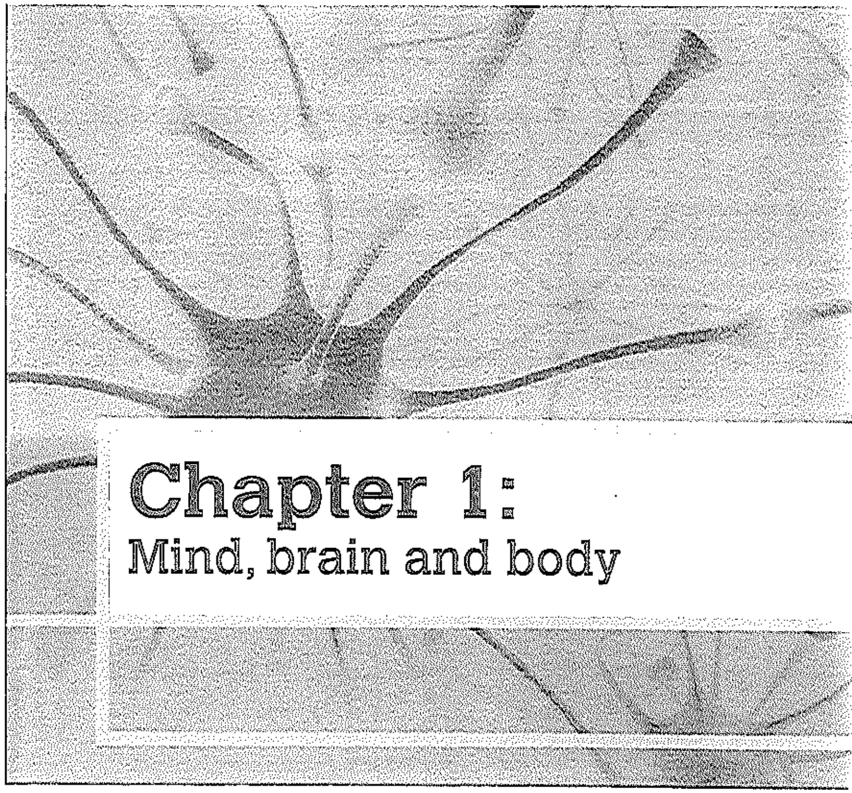


Chapter 1:
Mind, brain and body

Consciousness as a psychological construct

Consciousness refers to the awareness of an individual's own existence and mental activities (including thoughts, sensations and feelings) and of objects and events in the external world.

Consciousness is a hypothetical construct. It cannot be measured directly, but only inferred from an individual's self-reports and behaviour, or gauged using physiological changes as an indicator.

René Descartes

In the 17th century, René Descartes (1596–1650) proposed a **dualist** philosophy that the world comprised two distinct aspects – material elements that existed in space, and a thinking component that was conscious but had no physical location. While the brain is physical, Descartes claimed that the nature of thought is such that it has to represent a separate phenomenon, one that is unrestricted by physical laws.

Conscious experience, such as imaginings and **perception**, did not occur due to the stimulation of our sense organs or brain activity; but rather through the interaction between our physical body and the ethereal rational mind (or soul). Descartes saw the brain as being like a radio receiver that tapped into the non-physical dimension of the mind through the mediating pineal gland – the only brain component he could find that was not replicated in each hemisphere.

In a way, Descartes' ideas formed the foundation for a scientific approach to psychological phenomena, using empirical scientific methodology (based on the physical sciences) to explore hypothetical (non-physical) constructs.

William James' description of streams of consciousness

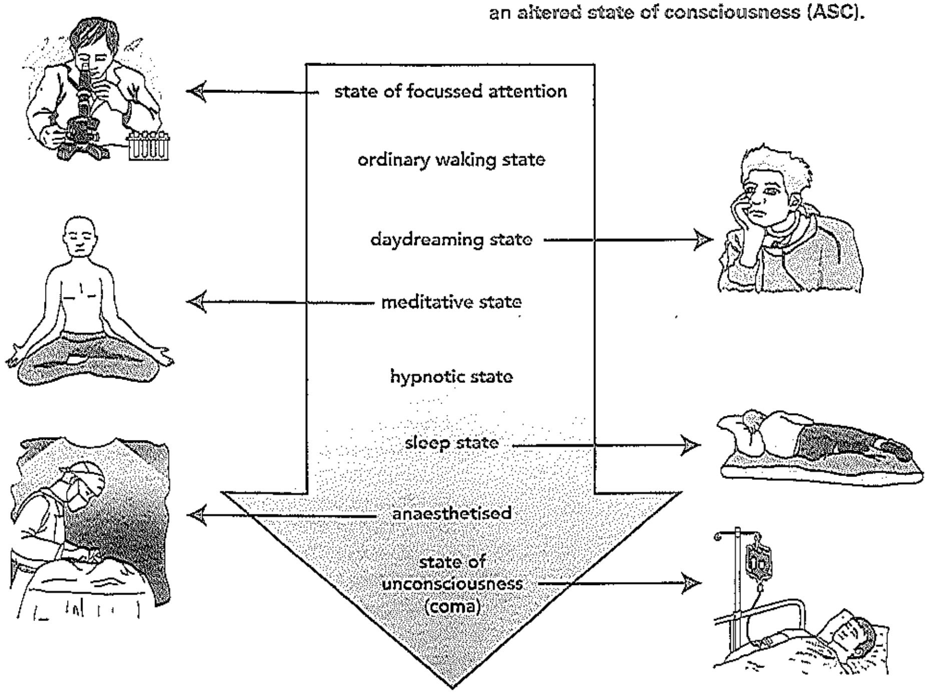
William James (1890) used the metaphor of a 'stream' to describe consciousness. This is because **sensations**, thoughts, feelings and perceptions continually change and merge into one another without ceasing, just as water does in a flowing stream.

Consciousness is, therefore: **continuous** and **changing**, as it goes on without stopping and its contents blend into one another; **subjective** or **personal**, because it incorporates our perceptions of our internal feelings/thoughts, and of our immediate external environment; and **selective**, as we can choose to focus on some things and ignore others.

Concepts of normal waking consciousness and altered states of consciousness

The term **state of consciousness** refers to the level of awareness that an individual has of both their internal processes and of external stimuli. Every individual experiences a range of different levels of consciousness throughout the progress of each day.

While in a state of **normal waking consciousness** (NWC), we are aware of the variety of sensory inputs from the outside world along with our thoughts, feelings and reactions to these inputs. As we spend the majority of our life in this state, most people assume without question that this is our experience of 'reality' and it is this state that provides the baseline by which we judge all other states of consciousness. Any state that deviates from this baseline is considered to be an **altered state of consciousness** (ASC).



Levels of Consciousness

Meditation is a process employing mental exercises to achieve a highly focused state of consciousness.
In its simplest form, meditation involves assuming a relaxed sitting or lying position and breathing deeply, slowly and rhythmically. Attention is directed only at the breathing movements of the diaphragm, with all other thoughts blocked from consciousness, thereby generating a sense of relaxation and an inner, private reality as an individual proceeds into a naturally induced altered state of consciousness.

Meditation may induce a state of physical relaxation by increasing alpha and theta brainwaves, and decreasing heart rate, respiration rate, oxygen consumption and carbon dioxide expiration. It is beneficial in reducing the experience of pain.

Daydreaming flows from normal waking state and is considered to be an ASC. An individual's attention has shifted away from external stimuli to an inner, private reality of self-generated thought and images. Daydreams can occur, on average, every 90 minutes during the waking period.
Unlike night dreams, daydreams are associated with few eye movements and high levels of alpha brainwaves (those associated with being in a relaxed state or in NREM1 sleep), and occur when we are awake. Even though we have control over the content of a daydream, it is even less organised and meaningful than night dreams. Thoughts are often disjointed, unrelated and emotional, and are usually positive and pleasurable.

It has been proposed that daydreams facilitate problem solving by allowing the mind to wander and think laterally, thinking over and rehearsing various courses of action, and enabling an individual to stay mentally alert.

Alcohol is a central nervous system depressant which, depending on the levels of alcohol in the blood and an individual's response to the drug, can affect people in a variety of ways. Some of the effects of alcohol can be attributed to an enhancement of inhibitory neurons using gamma-aminobutyric acid (GABA), which dampens the effect of many stimuli and responses, slowing down reaction times. Visual distortions may occur due to blurring or double vision, a narrowing of the field of vision and/or short-sightedness (alcohol myopia). Individuals under the influence of alcohol tend to lose their ability to focus and control their thoughts, often waffling on about random ideas that come to mind or becoming irrational. These cognitive difficulties can disrupt memory formation, sometimes leading to gaps in an individual's memory. While individuals may lose their inhibitions and become more sociable, loss of self-control may extend to coordination problems, poor judgement and risk-taking behaviours or emotional outbursts, including increased aggression and violence. Anaesthetic effects range from pleasant relaxation through to reducing a person's sensitivity to pain, making it possible to suffer injuries and not realise until the alcohol wears off. Larger amounts of alcohol will cause overdose, leading to loss of consciousness and possibly even death.

Behavioural effects for different levels of Blood Alcohol Concentration (BAC)

- 0.05 Person feels good, but less alert; slower reaction times
- 0.10 Reaction time decreases; individual becomes less cautious and loses inhibitions
- 0.15 Reaction time much slower
- 0.20 Sensory and motor abilities suppressed
- 0.25 Staggering (motor abilities severely impaired); perception is also limited
- 0.30 Semi-stupor
- 0.35 Level of anaesthesia; death is possible
- 0.40 Death is likely (respiratory failure)

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Normal waking consciousness	Altered states of consciousness and how they differ from normal waking consciousness
Awareness Aware of internal thoughts and feelings and of external stimuli through the senses.	**Awareness** Less aware of sensations and/or of external stimuli.
Attention Attention is focused on internal feelings and external stimuli and shifts of attention may be voluntary and involuntary.	**Perceptual distortions** Perceptual distortions may occur. Senses/feelings/emotions are experienced as stronger and more vivid, or are suppressed and blurred. There can be a loss or detachment from a person's sense of 'self'. Hallucinations can occur.
Perception Perception is clear, and the individual is able to process sensory input to form an awareness of their internal state and of external stimuli.	
Content limitations Content can be limited through selective attention to become organised and logical. Content remains for only a limited amount of time as consciousness is a never-ending flow of sensations and perceptions.	**Content limitations** Content is not as limited, often becoming illogical, disorganised and nonsensical.
Cognitive processes Individuals are aware of their thoughts, which are clear and meaningful. Thoughts are structured, focused and flowing. Individuals are capable of analytical thinking.	**Cognitive distortions** Individuals may lose touch with reality. Information processing is also distorted. Thinking may be illogical and non-sequential, and difficulties in problem solving and recall may be experienced.
Memory The brain actively stores information in memory and retrieves information from memory. Individuals are able to remember experiences and information processed in this state.	**Memory** Continuity in memory is disrupted, creating gaps or blackouts. It is often difficult to remember because information has not been processed into memory due to cognitive disruptions.
Time orientation Time is perceived as moving at a normal rate. Individuals also have an awareness of their place in time, and are able to focus on the past, present or future.	**Disturbed sense of time** Estimation of time is distorted. Time may appear to slow down, or pass more quickly (as when meditating). Individuals may also have no sense of time (as when asleep).
Emotional awareness Individuals are aware of their feelings and show a normal range of appropriate emotions.	**Changes in emotional feeling** Individuals become more emotional or emotionless. Inappropriate emotional reactions may occur and unpredictable emotional responses may result.
Levels of awareness There are various levels and degrees of awareness in normal waking consciousness. **Controlled processes** Information processing requiring conscious, alert awareness and mental effort in which the individual actively focuses their attention towards achieving a particular goal. **Automatic processes** Processes requiring little conscious mental effort and awareness, minimal attention and that don't interfere with other activities.	**Self-control** Difficulty maintaining self-control, coordinating and controlling movements, and maintaining control of emotions may be experienced. Inhibitions are often lost, and individuals engage in unusual or risky behaviours. People become more open to suggestion than normal.
Autonomic processes Uncontrolled/autonomic processes operate within normal parameters.	**Autonomic processes** Autonomic processes increase or (more often) decrease in their level of activity.

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Characteristics of sleep

Sleep is an altered state of consciousness marked by reduced metabolism and lowered consciousness. Sleep consists of different stages, each of which can be distinguished by characteristic physiological responses, including brainwave patterns, the presence or absence of rapid eye movement, and changes in heart rate, breathing rate, body temperature and muscle tone.

Rapid eye movement (REM) sleep

REM sleep is a stage during the sleep cycle in which electrical brain activity is characterised by erratic, low voltage **beta wave** patterns similar to those observed during the waking state. REM sleep begins about 1½ hours after we fall asleep and returns four or five times a night, becoming more frequent and longer towards morning. It is during this stage of sleep that most vivid night dreaming occurs.

The characteristics of REM sleep include bursts of rapid eye movements back and forth under your eyelids, irregular breathing, an increased heart rate, and **brainwaves** with irregular bursts of high-frequency, low-voltage beta waves. Below the neck, nerve impulses that travel down the spinal cord to body muscles are blocked, causing the muscles to be limp. Control of your body temperature is impaired so that you do not sweat when you are hot or shiver when you are cold. REM sleep is sometimes referred to as paradoxical sleep because the brain is showing a high level of activity while the body is inactive and extremely relaxed (to the point of paralysis).

Non-rapid eye movement (NREM) sleep

NREM sleep incorporates those stages of sleep not associated with rapid eye movements which contain little dreaming, and during which an individual is able to move. During NREM sleep, body temperature falls, breathing and heartbeat are regular, and brainwaves are slow and rhythmical. We have little conscious experience at these times.

NREM sleep consists of several stages, designated by changes in brainwave patterns, ranging from drowsiness through to deep sleep. In the early stages (stages 1 and 2), you awaken easily and may not even realise that you have been sleeping. In the deeper stages (stages 3 and 4), it is very difficult to wake up and if you are aroused you are likely to find yourself disoriented and confused. In NREM sleep your muscles are more relaxed than when you are awake, but you are able to move (although you tend not to because the brain is not sending signals to the muscles to move).

Adults spend approximately 80 per cent of their night's sleep in NREM and, typically, the first half of the night has more NREM sleep than the second half.

The purpose of sleep

Restorative function

The **restorative theory of sleep** describes the purpose of sleep as performing vital processes such as energy storage, muscle detoxification, the repair of body cells and tissues, and **neurotransmitter** replenishment. NREM slow wave sleep is essential to the physical growth and repair of the body, and may help recuperation from physical activity or illness, whereas REM sleep may help enhance brain development, facilitating the formation of synapses and consolidation of long-term memories.

However, it is not proven exactly what sleep specifically restores. If restoration is the only purpose of sleep, then inactive persons, such as disabled individuals who are confined to bed, should sleep less than the average active adult; however, this is not the case. Further to this, lowered body temperature and metabolic rate during sleep are more consistent with the body conserving itself rather than restoration or rejuvenation.

Survival (evolutionary) theory

The survival (or evolutionary) theory of sleep proposes that organisms sleep to conserve their energy and protect themselves during the most risky or dangerous times of the day when they are most vulnerable. While sleeping, the individual is inactive and therefore less likely to attract the attention

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of predators. This theory also accounts for between-species differences in sleep times because more vulnerable species sleep less than less vulnerable animals.

This theory, however, does not account for the fact that sleep involves a loss of awareness which detracts from survival, as the individual is not as ready to respond to danger if their muscles are in a relaxed state and their senses less attuned to their surroundings.

Measurement of responses which can indicate different states of consciousness

The self-report method of measuring states of consciousness is a useful subjective measure; however, individuals may be dishonest, be unable to describe their experiences in words, or forget, intentionally or unintentionally, to provide crucial information to the researcher.

Behavioural observations, including the use of video monitoring, are useful in demonstrating some of the effects of altered states, but these are limited as they tell the researcher very little about what is actually happening inside the body.

Physiological responses

Physiological responses give a better indication of differing states of consciousness, as these are objective measures that also provide information about bodily functions in those states.

Heart rate

Heart rate may increase during certain altered states of consciousness involving increased arousal, but generally heart rate will decrease during states such as relaxing, meditating, and sleeping or while unconscious. This can be measured/recorded using an **electrocardiogram** (ECG).

Galvanic skin response (GSR)

The **galvanic skin response** (GSR) indicates the activity of the sweat glands by measuring the electrical conductivity of the skin to gauge an individual's level of arousal. Increased activity of the sweat glands leads to higher electrical conductivity (or, conversely, lower resistance) across the skin.

The galvanic skin response may show an increase in electrical conductivity in states involving heightened emotions or would decrease in states involving lowered arousal, such as meditation or sleep.

Body temperature

Although body temperature does not vary much, researchers have found that body temperature drops by about 1 °C while we are asleep. If body temperature rises dramatically, as in a fever, an altered state of consciousness may be induced.

Muscle tension

The **electromyogram** (EMG) detects, amplifies and records electrical activity in muscles, generally via electrodes attached to the jaw/lower face. It is used in sleep laboratories to measure muscle tension which is extremely lax (to the point of paralysis) during REM sleep. Lowered levels of muscle tension would also be evident in other altered states, such as relaxation or meditation.

Eye movement

An **electro-oculargram** (EOG) measures eye movements by detecting, amplifying and recording electrical activity in the muscles around the eyes via electrodes attached to the upper face. Rapid eye movements indicate that an individual is in dream sleep.

Electrical activity of the brain

The **electroencephalograph** (EEG) is a device that is used to record patterns of electrical impulses produced by **neurons** activated in the brain. These impulses are measured via electrodes placed at various points on the surface of the subject's scalp. The changes in electrical activity within the brain are produced on graph paper as brainwave tracings known as an electroencephalogram.

Brainwaves differ from the normal waking consciousness to other altered states. The normal waking state is characterised by high-frequency, low-voltage beta wave patterns. Slightly larger **alpha waves** are present when we are daydreaming or in a relaxed or meditative state. Other progressively larger brainwaves (theta and delta) can be observed during sleep, which is why EEGs are used in sleep laboratories.

Several methods used to measure physiological responses begin with E (electro), referring to the measurement of electrical impulses, and finish with G (graph or gram), referring to the fact that the impulses measured are then represented in graphical form. The central part of each term relates to the specific physiological response being measured by the device.
ECG: Cardio = heart
EEG: Encephalo = brain (make an association with encephalitis, inflammation of the brain or hydrocephalus, water on the brain)
EMG: Myo = muscle
EOG: Ocular = eyes (the word 'optic', which also begins with the same letter, may reinforce the association with eyes)

HOT TIP When defining each method within a short-answer question, remember **DARE**: each device **D**etects, **A**mplifies and **R**ecords **E**lectrical activity.

Identifying EEG brainwave patterns

Amplitude refers to the height or size of the peaks and troughs, indicating the level of voltage within the electrical impulses.
Frequency refers to the number of brainwaves per second.

To remember the brainwaves as we descend from being awake to deep sleep, think of the acronym:
BATheD (Beta, Alpha, Theta, Delta).

To recall the size of the waves as we descend through them, imagine that you are in a highly active/agitated state and have to draw brainwaves. Without lifting your pen, gradually allow yourself to relax.
The shape of your waves would be similar to the diagram below.

Initially the waves would be small (high frequency) and progressively get larger (less frequent).

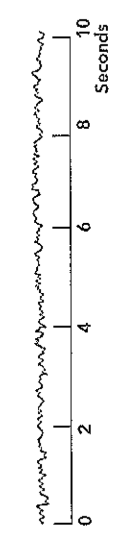
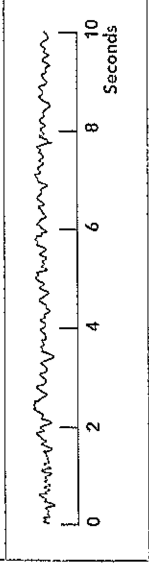
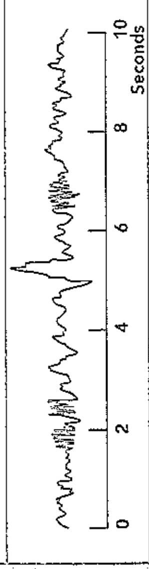
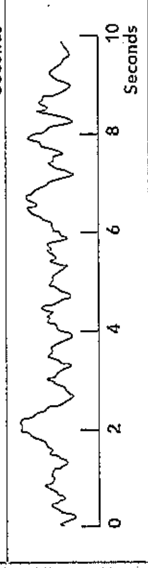
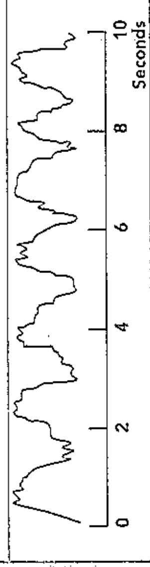
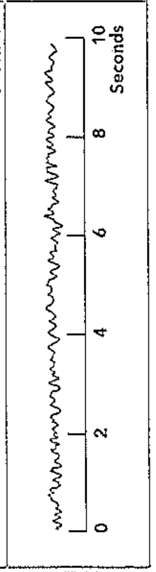
Pattern of the stages of sleep

The hypnagogic state is the dreamlike 'twilight' state between wakefulness and entering NREM stage 1. During this state, we begin to lose voluntary control over body movements, our sensitivity to external stimuli diminishes, and our thoughts become more fanciful and less bound by reality.

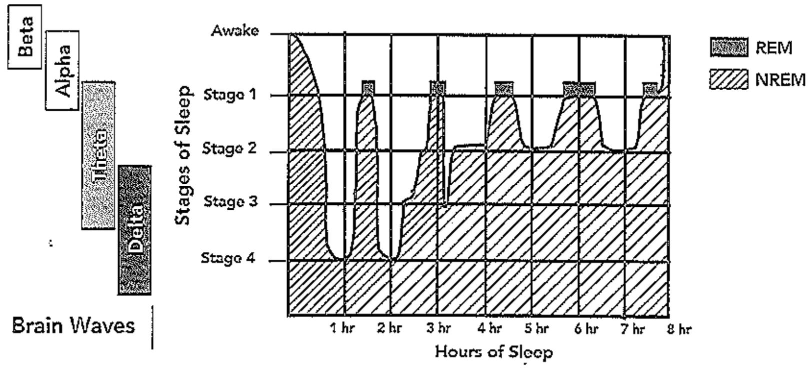
NREM sleep includes four sleep stages with the following characteristics:

- **stage 1** – breathing is irregular, muscles relax, **hypnic jerks** occur, brainwaves are irregular and small, with some alpha brainwaves progressively getting bigger to theta waves
- **stage 2** – **sleep spindles** and **K complexes** occur within theta brainwaves, lowered body temperature
- **stage 3** – as well as **theta waves**, delta brainwaves appear which are large and slow
- **stage 4** – deep sleep, pure delta brainwaves.

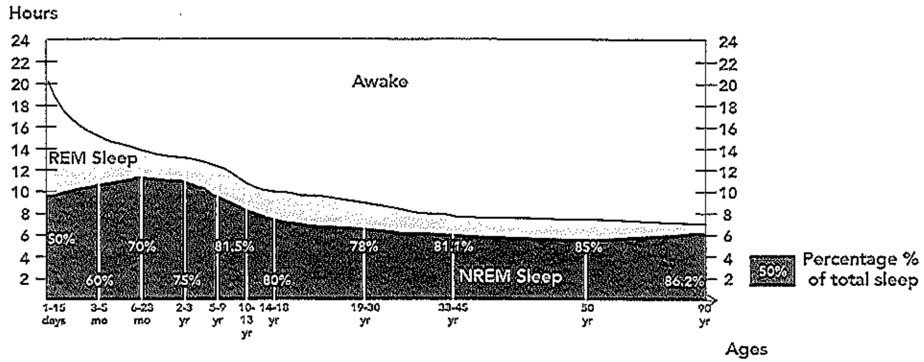
An adult sleeps for approximately eight hours per night, progressing through cycles of about 1½ hours. Periods of deep sleep (NREM4) occur earlier in the night, and periods of REM sleep occur, on average, every 90 minutes. The depth of NREM sleep gets progressively shallower with each cycle as the night goes on.

Sleep stage	EEG pattern	Description of EEG pattern	EMG pattern	EOG pattern
Awake (NWC)		An awake, alert state with beta waves (high frequency, low amplitude).	High amplitude, often with distortions.	Active, may be spiky with eye blinks.
NREM Stage 1 (Drowsy)		There is a decrease in alpha waves from the awake, resting state, and more lower-frequency, irregular amplitude theta waves are present.	High amplitude, but not distorted.	May be rolling eye movements.
NREM Stage 2 (Light sleep)		Theta waves are lower in frequency and higher in amplitude than they would be in stage 1. Sleep spindles (high-frequency bursts) and K complexes are also present.	Medium amplitude.	No eye movements.
NREM Stage 3		As well as theta waves, there are quite a few higher-amplitude and lower-frequency delta waves present.	Medium or low amplitude.	No eye movements.
NREM Stage 4 (Deep sleep)		Delta waves are very low in frequency and very high in amplitude.	Medium or low amplitude.	No eye movements.
REM (Rapid eye movement)		Rapid eye movement sleep characterised by irregular bursts of high-frequency, low-amplitude beta waves.	Low amplitude.	Sharp, intermittent eye movements.

An adult experiences a total of 1–2 hours REM sleep a night, in four sessions, each session progressively increasing in length as the night goes on, starting from 10 minutes in length to 30+ minutes in the morning.



The graph below depicts the amount of hours spent sleeping as an individual ages and the percentage of total sleep time spent in REM sleep.



As individuals age, they require less total sleep per 24-hour period. Newborns sleep almost all the time – up to 17–18 hours. Infants cycle through many sleep periods throughout the day. As they develop, they sleep longer at night and have fewer sleep periods during the day. Ten-year-olds sleep for 9–10 hours, adults sleep 7–8 hours, and,the elderly sleep 6 hours with less deep sleep. Thus, there is a strong negative correlation between total hours slept per night and age.

The percentage of total sleep time spent in REM sleep also lessens as an individual gets older. For example, a newborn spends approximately 50 per cent of total sleep time in REM sleep compared to an adult, who spends approximately 20 per cent of their time in REM sleep. The fact that infants show a higher proportion of time in REM sleep is seen as supporting the notion that REM sleep aids in the formation of synapses.

Throughout childhood, children typically get about 10 hours of sleep a night, but this drops significantly in adolescence.

Adolescent sleep patterns

Sleep researchers now recognise that there are distinctive changes in sleep patterns in adolescence. The rapid physiological, emotional, and social changes of adolescence often have disturbing effects on sleep. Teenagers need more sleep but often do not get the amount required,

especially during the school year, and thus are constantly coping with sleep debt.

The consequences of insufficient sleep in adolescents causes many problems, including poor schoolwork and/or absenteeism, daytime fatigue and drowsiness, decreased motivation, and difficulties with self-control of attention, concentration, short-term memory, emotion and behavioural issues, such as irritability, hyperactivity, and impulse-control problems.

Teenagers demonstrate a biological 'phase delay' of sleep patterns, leading to a tendency for a later shift of the sleep/wake cycle because of changes to the internal body clock governing circadian (24-hour) biological rhythms that occur at puberty. Even adolescents who have experienced **sleep deprivation** (and therefore accumulated some sleep debt) tend to feel more alert in the evening, thus making it more difficult to go to bed at what parents might consider a reasonable hour.

Teenagers are therefore particularly susceptible to **delayed sleep phase syndrome (DSPS)**, which involves an inability to reset the sleep/wake cycle in response to environmental time cues, resulting in a misalignment of the timing of sleep, peak period of alertness, core body temperature, hormonal and other daily rhythms relative to societal norms. Adolescents with DSPS often lie awake in bed for a long time, unable to fall asleep until some hours after midnight and have difficulty waking up at the desired time in the morning. Unlike most other insomniacs, however, they fall asleep at about the same time every night, no matter what time they go to bed.

Many teens try to compensate by catching up on their sleep on weekends by sleeping nearly two hours longer on average, and/or by taking long naps during the day. To some extent this may provide relief from daytime drowsiness, but irregular sleep schedules also pose problems by perpetuating the late sleep phase and disrupting the normal sleep cycle.

Effects of sleep deprivation

Sleep deprivation involves a lack of sleep which can lead to a variety of physiological and psychological effects.

The symptoms of sleep deprivation

The typical effects of a short period of sleep deprivation include lethargy, irritability, headaches, loss of concentration, inattention, difficulty completing low-level boring tasks, inefficiency, confusion or misperception. When allowed to go to sleep, individuals would fall asleep more quickly and sleep longer than usual.

The symptoms of severe sleep deprivation include more pronounced inefficiency and fatigue, visual hallucinations, disorientation and psychotic behaviour including paranoia and delusions. These are all temporary. Once allowed to catch up on their sleep by getting a few extra hours over the days subsequent to their deprivation, individuals display no long-term harmful effects from such sleep loss.

REM rebound occurs after being selectively deprived of REM sleep. People spend more time than usual in REM sleep over the next few nights indicating a need to make up for lost REM sleep. They also become anxious, irritable and angry, experience difficulty concentrating and may hallucinate.

Total sleep deprivation is difficult to measure because after three or four sleep-free days, individuals involuntarily drift into **microsleeps**, which are short periods of drowsiness or sleep which intrude into the waking state.

Performance on complex intellectual tasks is not impaired by sleep deprivation. However, an individual's ability to follow simple routines is affected, as well as their vigilance, attentiveness and mood. Low-level boring tasks are the most likely to be affected, as sleep deprivation may affect motivation rather than ability.

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The divisions of the nervous system

The central nervous system (CNS)

The **central nervous system (CNS)** includes the brain and the spinal cord. The **spinal cord** plays two major roles in connecting the brain to other areas of the body:

- it passes sensory information along sensory neurons from the peripheral nervous system to the brain
- it transmits information from the brain to the peripheral nervous system which activates motor neurons to which muscle cells respond.

The peripheral nervous system (PNS)

The **peripheral nervous system** links the central nervous system to other parts of the body and is divided into the somatic nervous system and the autonomic nervous system.

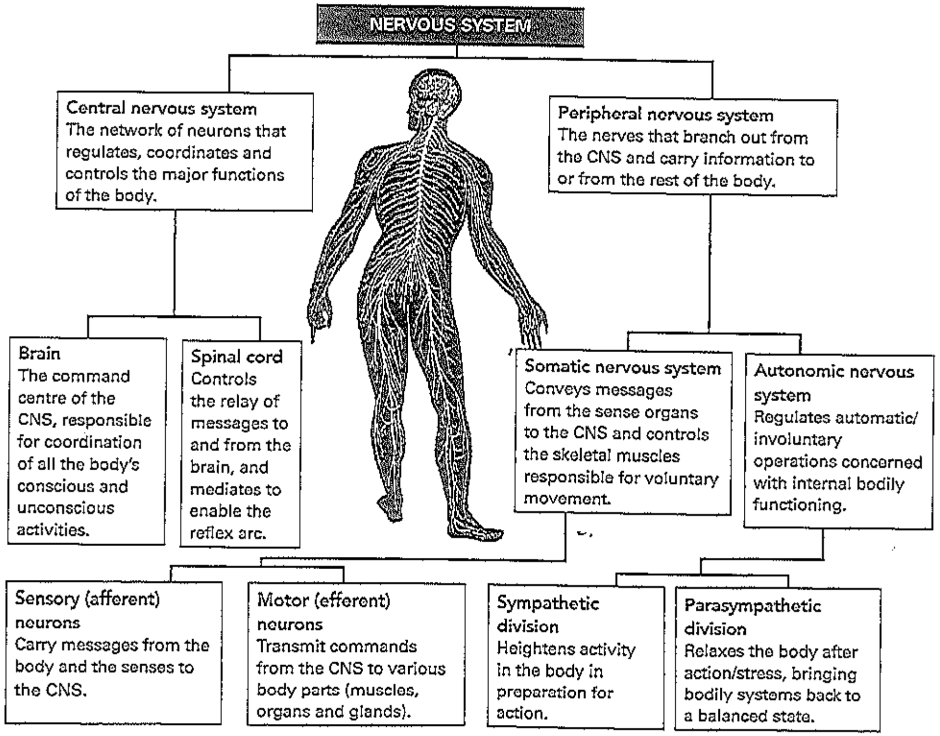
The role of the somatic nervous system in the control of skeletal muscles

The **somatic nervous system** transports messages between the sense organs and the spinal cord. Via its connections with the **skeletal muscles**, it also controls voluntary bodily movements.

Nerves from the somatic nervous system do **not** control any of the **non-skeletal muscles**, such as the heart, lungs, stomach or intestines.

Distinction between sensory and motor neuron activity within the somatic nervous system

Sensory (afferent) nerve fibres receive sensory stimuli arising inside or outside the body and transmit them inwards to the central nervous



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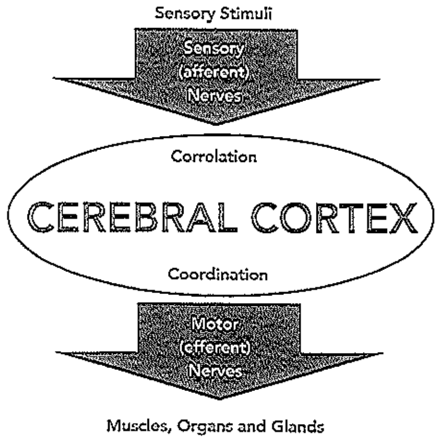
system where they are correlated. The **motor (efferent) nerve** fibres transmit information outwards, away from the central nervous system, enabling the coordination of effector organs such as muscles and glands. This allows them to work harmoniously ensuring the wellbeing of the individual.

> To remember the different names for the two types of neurons, use the acronym SAME where the letters stand for Sensory (Afferent) neurons and Motor (Efferent) neurons.



The role of the autonomic nervous system in the control of the non-skeletal muscles

The **autonomic nervous system (ANS)** controls *involuntary* bodily activities, such as digestion and heart rate, when nerves transmit information to and from the glands and internal organs enabling a balanced state.

The main functions of the sympathetic and parasympathetic nervous systems

When the 'fight-or-flight' response is activated, the **sympathetic nervous system** is turned on, initiating some responses and inhibiting others, to mobilise the body to deal with an emergency situation.

Once the emergency situation is over, the **parasympathetic nervous system** conserves bodily functions by restoring the body to a balanced state of homeostatic equilibrium.

> To remember the different divisions of the autonomic nervous system, associate the sympathetic branch with arousal and/or stress. Imagining a parachute floating down to the ground may help you to remember the prefix for the parasympathetic branch, which brings physical mechanisms back down to normal levels again, relaxing the body after arousal.

The physiological systems involved in arousal

The 'fight-or-flight' response

Arousal refers to the general level of alertness and activation of an organism.

The **physiological responses** associated with arousal are produced when the fight-or-flight response is triggered by the hypothalamus, activating the sympathetic division of the autonomic nervous system. The **fight-or-flight response** refers to a state of arousal that prepares or mobilises the body to confront a situation or 'fight' it or, alternatively, flee from a situation, hence the term 'flight'.

Typical responses would include:

- high levels of adrenaline (speeding up heart rate and response time)
- increased heart rate and blood pressure (to carry more oxygen to the body)
- increased respiration (breathing) rate (to supply more oxygen to the blood)
- increased muscle tension (to enable quicker reaction time)
- sweating (leading to increased electrical conductivity of the skin)
- 'goose bumps' forming on the skin
- inhibited digestion and 'butterflies' in the stomach
- dilated (widened) pupils (to allow more information to be gathered quickly)
- dry mouth (due to saliva inhibition)
- release of sugar from the liver (to supply energy to the body)
- an increased need to urinate (due to a relaxed bladder).

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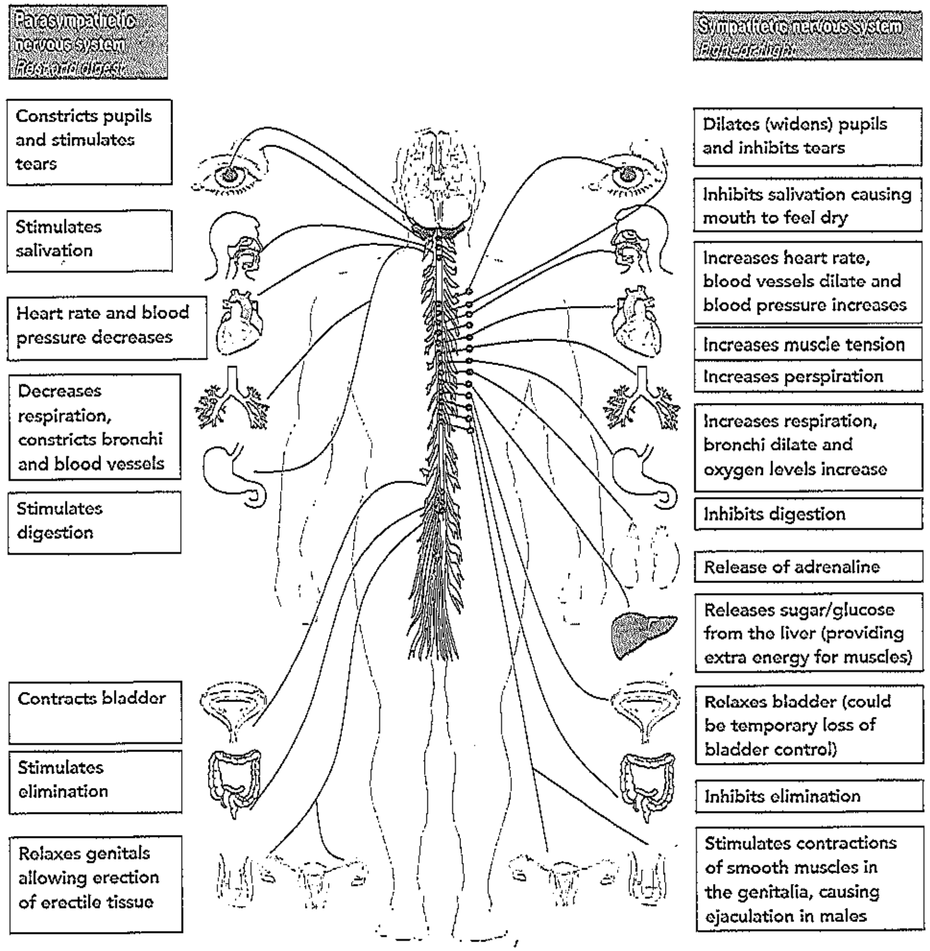
The main functions of the sympathetic and parasympathetic nervous systems



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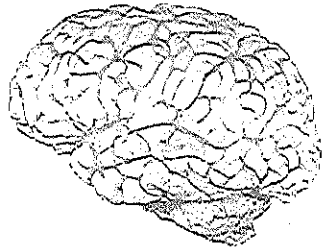
The brain

The average human brain weighs about 1.4 kg and is made up of approximately 100 billion interconnected neurons (or nerve cells). While they are useless as single entities, when these neurons are chained or linked into vast networks, they form the nervous system which regulates, coordinates and controls the major functions of the body. Neurons specialise in carrying and processing information and relaying messages between the central nervous system (brain and spinal cord) and the peripheral nervous system, as well as activating glands and muscles.



Neurons – building blocks of the nervous system

Information is transmitted electrochemically from one neuron to the next via neurotransmitters, which are a variety of different chemicals capable of altering the electrical activity or interior charge in other neurons.

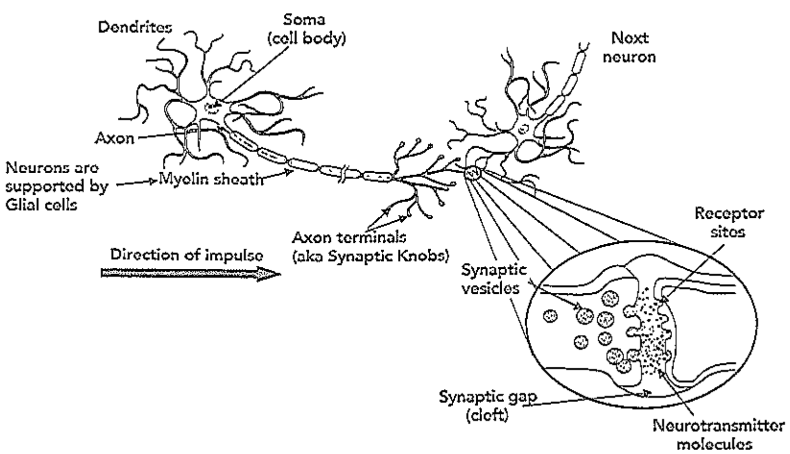
Neurotransmitters are stored inside synaptic vesicles. When a neural impulse occurs at an axon terminal (aka synaptic knob), these vesicles move to the surface of the neuron and release the appropriate neurotransmitters.

These neurotransmitters cross the synaptic gap (cleft) between neurons. This is a microscopic space between the pre-synaptic axon terminal and the post-synaptic dendrite of the next neuron which changes its activity after the neurotransmitter attaches to receptor sites.

Communication between neurons

Receptor sites are areas on the surface of the receiving neuron that are sensitive to both neurotransmitters and hormones. The chemical reaction at the receptors sets up an action potential which is passed as an electrical impulse along the axon to the next set of synapses. The electrical activity within the axon is insulated by a fatty layer known as the myelin sheath.

Neurons – building blocks of the nervous system



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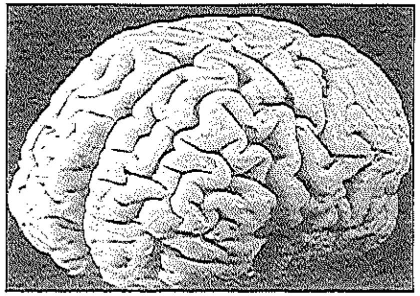
The structure of the cerebral cortex



Surrounding the central structures of the brain are the two halves known as the **cerebral hemispheres**. The outer covering, the **cerebral cortex**, is composed of densely packed nerve cells – the grey matter – forming a spongy, wrinkled layer about 3–4 mm thick surrounding the white matter of the cerebrum. The surface of each hemisphere is highly convoluted (wrinkled) to increase the surface area available within the confines of the skull, such that it contains at least 70 per cent of the neurons in the CNS, with distinct regions responsible for particular functions. The cortex is important in controlling the higher behavioural functions, such as learning, memory, thinking and perception.

The **corpus callosum** is a large, dense bundle of nerve fibres linking the left and right cerebral hemispheres of the brain. Its function is to enable these hemispheres to communicate with one another, disseminating information from the cerebral cortex on one side of the brain to the same region on the other side. The front portion may allow the exchange of emotions, thoughts and meaning, whereas the back portion is thought to transfer sensory and perceptual information between the two hemispheres.

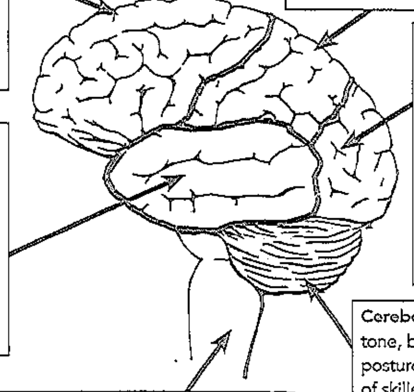
The functions of the four lobes of the cerebral cortex

Each hemisphere of the cerebral cortex is divided into four **lobes** which have specific roles in controlling motor, somatosensory, visual, and auditory processing in humans. These are located in the **frontal lobes**, **parietal lobes**, **occipital lobes**, and **temporal lobes** respectively.

The functions of the four lobes of the cerebral cortex

Frontal lobe – enables higher mental functioning involving learning and memory, and control of complex movements, including the mechanics of speech (Broca's area). This region also controls emotions, personality and intellectual tasks requiring reasoning and planning.

Temporal lobe – the main location where auditory information is projected, enabling registration and understanding of hearing, including language comprehension. This lobe incorporates the hippocampus, which plays a major role in memory formation, learning, and recognition.



Parietal lobe – mediates attention and is involved in spatial perception and bodily awareness based on sensations of touch, pressure, pain and body movement.

Occipital lobe – the primary visual area of the cortex, enabling perception.

The Occipital lobe processes Optical (Ocular) information.

Cerebellum – controls muscle tone, balance (including posture) and the coordination of skilled movements. It therefore aids the storage of procedural memories.

Spinal cord – controls the relay of messages via nerve fibres to and from the brain, and mediates to enable the reflex arc.

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Motor cortex – directs the muscular control in the body enabling fine, coordinated movement of body parts.

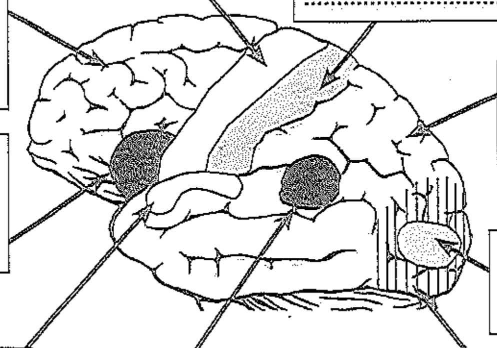
The motor cortex controls movement of voluntary muscles

Somatosensory area – registers bodily (somatic) sensations such as touch, temperature, pressure, pain and body movement.

'Soma' is Greek for 'body'. Therefore, breaking the word 'somatosensory' into its parts reveals its function to process bodily sensations.

Association areas – process and combine information from the senses and relate to higher mental abilities.

Broca's area – controls muscles enabling the ability to use language, encompassing speaking and writing.



Association areas – processes and combines information from the senses and relates to higher mental abilities.

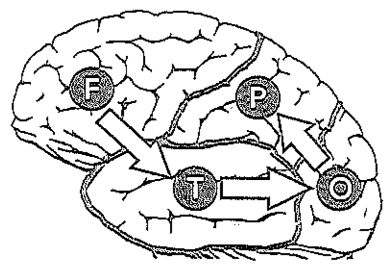
Primary visual cortex – processes information from our sense of sight to form perception.

Primary auditory cortex – receives and processes auditory information from our sense of hearing.

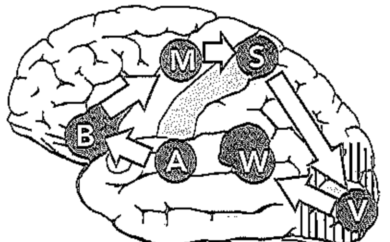
Wernicke's area – enables the understanding of the meaning of words.

Note: some sources portray the visual cortex as a wider area of the occipital lobe, as they combine the primary visual cortex with the visual association areas.

Also, the secondary visual areas are within the temporal lobes and assist in the recognition and understanding of visual input.



To remember the location of the four lobes of the brain, use the sequence F.TOP (or F TO P) where each letter represents the initial for one of the lobes (Frontal [at the front of the brain], Temporal [near our temples], Occipital and Parietal) in a rotational sequence within the brain (refer to the diagram).



To recall the location of the key functional areas within the cerebral cortex (as listed in the Study Design), use the first letters of the following sentence as a trigger: A Big Man Sings Very Well! These letters refer to Auditory cortex, Broca's area, Motor cortex, Somatosensory cortex, Visual cortex and Wernicke's area (refer to diagram).

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HOT TIP Make sure you know how to spell each of the lobes. Assessors are instructed to take answers at face value so, for short-answer questions or when labelling the brain, spelling is critical. Common errors include: 'partial' or 'parental' for 'parietal'; 'optical' for 'occipital'; and 'temple' or 'templar' for 'temporal'. Even though it might be clear what you meant to write, misspelt words will be marked as incorrect and receive NO marks.

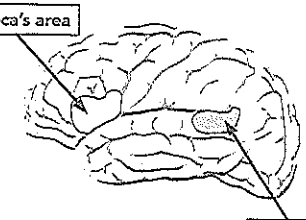
The language centres

Language centres		
Area	Broca's area	Wernicke's area
Hemisphere	In 95% of cases, language is processed in the left hemisphere of the brain.	
Lobe	Frontal lobe (adjacent to the primary motor cortex)	Temporal lobe (adjacent to the primary auditory area)
Function	• Controls the muscles associated with the use of language. • Responsible for producing clear speech that follows the rules of grammar. • Involved in understanding complex grammatical structures.	• Enables us to understand the meaning of spoken and written language. • Locates words from memory to express a particular meaning. • Creates meaningful, coherent and grammatically correct speech and writing.

Broca's area is next to the motor cortex, which enables the movement of muscles involved in speaking.

T U V W – In the Temporal lobe, we Understand Vocabulary (or Verbal language) through Wernicke's area. Alternatively, WILT (Wernicke's Interprets Language in the Temporal lobe).

Profile of brain highlighting location of language areas



Broca's and Wernicke's aphasia

Types of Aphasia

Aphasia (language disorder due to brain damage)		
	Broca's aphasia	Wernicke's aphasia
Caused by damage to	Broca's area	Wernicke's area
Also known as	Expressive aphasia Motor aphasia Non-fluent aphasia	Receptive aphasia Sensory aphasia Fluent aphasia
Speech (production and clarity)	Affected/impaired	Unaffected
Comprehension of language	Unaffected	Affected/impaired
Effects	• Difficulties in the production of language, most noticeably articulation (pronouncing words). • Speech tends to be slow and drawn out, requiring much concentration and effort. • Sentences and words tend to be very short. • Poor use of grammar. • Individuals are able to comprehend what others are saying and know what they wish to communicate.	• Inability to understand the meanings of words in spoken and written language. • Individuals often have trouble producing appropriate content words and may use incorrect or non-existent words, creating nonsensical phrasing. They are unaware of these errors. • Speech and pronunciation is unimpaired.

The association areas

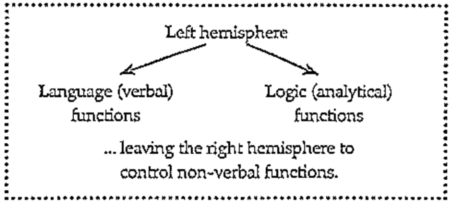
The different regions that control specific functions only take up a small portion of the cortex. Beyond these primary areas, the rest of the cortex comprises the **association areas**, which combine information in order to perform complex processing tasks using memory, language, problem solving and recognition. Cognitive tasks, which are frequently regarded as the main functions of the brain, take place in the association areas. The association areas are present in all of the lobes and are either connected by axons projecting directly from one area of the neocortex to another or through the thalamus.

Hemispheric specialisation

Left hemisphere	Right hemisphere
Verbal and analytical functions	Non-verbal functions
Controls **RIGHT** side of the body Right-hand touch Processes the right visual field Language – reading and writing Rational/logical/factual Sequential processing Mathematics and science Practical Past and present Cause and effect	Controls **LEFT** side of the body Left-hand touch Processes the left visual field Symbols and images Fantasy/imagination Holistic processing Appreciation of the arts Creative Present and future Perception and spatial skills

The **right hemisphere** of the brain mainly deals with non-verbal responses, including the recognition of faces, tunes and patterns, spatial skills, visualisation and manipulation, the detection and expression of emotion, and self-monitoring of behaviours. Information is processed holistically and simultaneously.

The **left hemisphere** of the brain, of a typical individual, deals with verbal and analytical functioning, including speaking, writing and language comprehension, logical thought encompassing mathematical ability, the judgement of rhythm and time, ordering complex movements and critical and analytical thought. Information is analysed and processed sequentially.



One way to establish which cerebral functions are localised to which hemisphere in patients with intact brains is through the **Wada test**. This test involves injecting a barbiturate through a catheter to anaesthetise one hemisphere at a time, thereby shutting down any language and/or memory function in that hemisphere for several minutes. The patient is then engaged in a series of language and memory-related tests in order to evaluate functions within the other hemisphere.

Brain injuries can also illustrate the specific abilities of each hemisphere of the brain.

An individual with damage in the left brain may be unable to speak, read, write or spell but may retain the ability of being able to hum a tune or draw. Conversely, an individual with right-brain damage may lose their way while driving a car or have difficulty interpreting diagrams.

In terms of language comprehension, a person with left-brain damage may be able to detect the emotional tone in another's voice and therefore differentiate between sarcasm, love and anger. However, they may not comprehend the content of what is said. Alternatively, a person with right-hemisphere damage can understand what is said but is unable to recognise the emotional tone in which it is spoken.

Spatial neglect

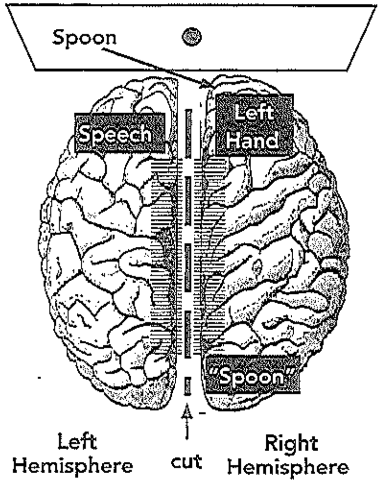
Spatial neglect typically occurs when the parietal lobe in the right hemisphere of the brain has sustained damage through a stroke or brain injury, resulting in a patient's failure to pay attention to items on their left side as if there is no left side at all. When shown a complete illustration and asked to replicate it, patients may only draw the right side, and outlines may be distorted. When asked to draw what they wish, patients' subject

matter may be bizarre, illogical or repulsive in nature. Patients will see only the right side of compound words, such as only seeing 'ball' instead of 'football'. In addition, patients may eat just from the right side of the plate or only dress the right side of the body and shave the right side of the face, ignoring the left side. While they are not actually blind to objects on the left, the full attention circuit is not activated on this side, making them effectively blind. Because the right hemisphere controls facial recognition and emotion, patients may have poor relationships with others and may be unable to recognise them.

Split-brain studies

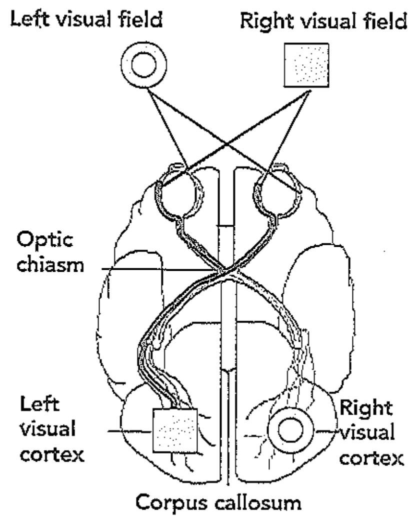
In some cases, patients with severe epilepsy underwent a form of surgery known as a **'split-brain'** operation, in which the fibres of the corpus callosum were severed, dividing the left and right hemispheres of the brain. As a result, these patients often experienced a doubled consciousness, as each hemisphere of the brain would experience unique sensations and perceptions and act accordingly. Therefore, one hemisphere may be unaware of the activity of the other hemisphere.

The work of Sperry and Gazzaniga



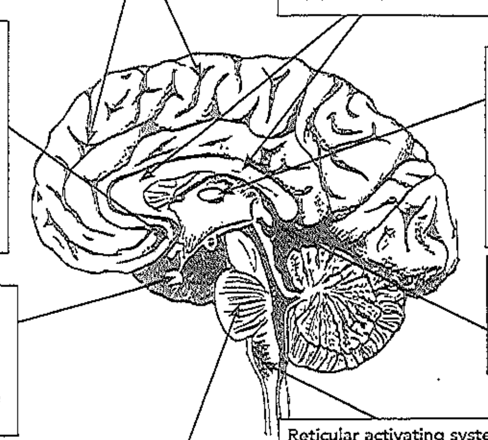
Studies by Sperry and Gazzaniga have found that, while 'split-brain' patients appeared quite 'normal', difficulties coordinating actions such as dressing could be experienced. Only after careful experiments that isolated information from reaching one hemisphere, could the real effects of the surgery be determined. Typically, in such patients, only the left hand is able to solve geometric puzzles involving spatial skills.

Patients were also able to describe images projected into the right visual field, but could not do so if the same image was projected onto the left visual field. The same kind of finding was also evident for touch and sound. Information can, however, still be transmitted to both hemispheres via the optic and auditory pathways, and so 'split-brain' patients may show little change in their behaviour, except in situations (such as experiments) when a stimulus is presented to only *one* of the two cerebral hemispheres.



Methods of research on patients with brain damage can be criticised, as the subjects of such studies were not normal and so might not be representative of the whole population.

Key brain structures involved in consciousness, arousal and attention



The role of the reticular activating system in selective attention and wakefulness

The **reticular activating system** (RAS) is a structure in the brainstem that is responsible for sustaining consciousness, directing attention to sensory events, and mediating various levels of alertness and general arousal mechanisms.

The reticular activating system is crucial for maintaining our state of consciousness, controlling sleep and wakefulness. When the RAS is operating, the individual is awake, alert, aroused and attentive. Alternately, a reduction in its activity results in inattentiveness or drowsiness and eventual sleep, or in the extreme (such as under anaesthesia or concussion) may lead to confusion or unconsciousness. Serious damage to the RAS can lead to permanent coma.

Due to its limited capacity, the brain cannot simultaneously process all available sensory information. The RAS limits the amount of information admitted to the brain by filtering out irrelevant aspects before relaying sensory impulses from the body to the cerebral cortex via the thalamus. In this way, the RAS enables us to be aware and knowledgeable about our environment while controlling the various shifts in an individual's attention and level of involvement in various activities. The RAS also allows us to monitor things around us subconsciously, so that we can quickly redirect our attention to respond to new or important stimuli, such as when you hear someone use your name in a crowded room or when you are woken from your sleep by an unusual noise in your house.

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The role of the thalamus

The **thalamus**, a structure deep within the forebrain, has long been regarded as the key relay station that directs the flow of information being sent to, from or within the brain, filtering out only information of particular importance from the mass of signals entering the brain.

Newer research suggests that it also plays a major role in regulating arousal, including levels of sleep and wakefulness, along with our level of awareness and activity. Most people think that they are essentially cut off from their senses while they are asleep, but any stimulus can wake us up if it is sufficiently above an individual's sensory threshold. The reason why the brain can block out certain stimuli to allow us to go into sleep mode, yet still allow important input to register, is due to the thalamus.

Studies investigating the cognitive processes of the brain

Until recently, the possibility of investigating the brain's ability to create a perception of our humanity was thought to be too difficult as consciousness was regarded as merely an individual, personal experience. Still controversial in terms of its description and measurement, our understanding of consciousness has been deepened by developments in cognitive neuroscience, which is one of the fastest growing and most exciting contemporary fields of scientific inquiry and imaging technology.

To date, neuroscientists have not been able to locate a single brain area that, when damaged, removes consciousness yet leaves all other functions intact. The more scientists learn about the brain, the more they see it as a vast, integrated system in which information flows in and out along complex and parallel pathways. The existence of a specific area where consciousness 'exists' therefore seems unlikely.

Early methods of exploring the brain and its functions involved doing autopsies on patients who had suffered from speech difficulties, paralysis or other types of neurological problems as a result of birth injuries, head wounds or strokes.

A **stroke** involves damage to part of the brain caused by interruption to its blood supply (due to thrombosis or an embolism) or by leakage of blood through the walls of blood vessels (haemorrhage). When a section of the brain is temporarily deprived of oxygen, which is carried by blood, nerve cells in the affected area cannot function and die quickly, causing damage to that area, thereby leading to symptoms which may include paralysis (especially on the side of the body opposite to the site of the stroke), **aphasia** (disturbance of language and speech), loss of consciousness and brain function, coma, convulsions and other neurological signs determined by the location of the stroke.

When an autopsy revealed a tumour or some other abnormality in a specific area of the brain, it was assumed that this area was responsible for the function affected in the patient. This method led to the discovery of the language/speech centres (Broca's area and Wernicke's area) discussed earlier in this chapter.

In other cases, it was possible to observe changes in the behaviour of patients who had survived severe head trauma. In the case of Phineas Gage, an accident drove a metal rod through his head, causing terrible damage to his frontal lobes. Even though he lived for 12 years after the incident, his personality had been destroyed.

Perceptual anomalies

Visual sensation and visual perception are interrelated as they work simultaneously as parallel processes.

Visual sensation is a physiological process whereby light (electromagnetic energy) from environmental stimuli is collected by the eyes and transformed into electrochemical (neural) impulses that are then sent to the occipital lobes of the brain. This process is similar for all individuals with normally functioning sensory systems.

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Visual perception is an active physiological and psychological process that results in a meaningful interpretation of the information. Perception can be unique for each individual as it can be affected by a range of psychological factors.

The individual differences that can occur during the process of perception can result in **perceptual anomalies** whereby the objective reality of an existing physical stimulus is inconsistent with an individual's subjective perception. Such phenomena caused Descartes to question how accurate observations of the physical world could be, leading to his dualist theory of consciousness. Other researchers use these phenomena to explore how we process incoming information in order to adapt and respond to environmental stimuli.

Motion after-effect

The **motion after-effect** is a visual illusion creating the perception of motion where there is none. It is experienced when fixating a stationary stimulus after watching a moving visual stimulus with stationary eyes for an extended period (from several seconds to a minute). The stationary stimulus then appears to move in the opposite direction to the original (physically moving) stimulus.

It has sometimes been referred to as the *waterfall illusion* since Adams (1834) described the effect when, after staring at a waterfall for about a minute, the stationary rocks beside it appeared to be moving upwards slightly for a short time afterwards.

Another example, the *spiral after-effect*, can be seen after looking at the centre of a rotating spiral, which can exhibit outward or inward motion, for several seconds. When an individual then looks at any stationary pattern, it appears to be moving in the opposite direction to the perceived motion of the spiral.

Most explanations focus on neural adaptation whereby perception of stationary objects is coded as the balance among the responses of neurons coding all possible directions of motion. Neurons responding to a particular movement tire after several seconds of continuous firing, reducing their baseline activity in favour of perception of movement in the opposite direction.

Another approach proposes that, rather than the firing of one group of neurons, perception of movement is due to the activity of one group of neurons (such as downward motion) relative to that of another group of neurons responding to motion in the opposite direction. Downward motion is indicated when the neurons coding for downward movement fire more strongly than neurons coding for upward motion. If the downward neurons now fire less strongly because of fatigue after several seconds of continuous activity, the balance between these two groups is disrupted such that perception of a stationary target would indicate movement in the opposite direction consistent with the non-inhibited neurons.

Change blindness

Change blindness is a phenomenon in visual perception in which very large changes occurring in full view within a visual scene are not detected by the observer.

A number of experimental studies suggest that, for change blindness to occur, the change in the scene typically has to occur at the same time as some brief disruption in visual continuity, such as a saccade (eye movement) or a brief masking of the observed scene due to a brief flicker, an eye blink, or a film cut in a motion picture sequence. When looking at still images, change blindness can be achieved by changing a part of the image.

The results of studies into change blindness suggest that humans' internal representation of the visual world is much sparser than usually thought. Wolfe (1999) proposed the idea of 'inattentional amnesia', where we see everything, but forget most of it immediately. Only a small portion of the icon's contents, namely the parts that have been attended to, would at any moment be transferred into memory and be available for doing tasks like change detection – the rest would be forgotten.

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Synaesthesia

Synaesthesia means 'joined sensation', referring to a condition whereby some people experience a sensory blending or crossover. Two or more senses are automatically and involuntarily coupled, such that music is not only heard, but also felt, seen or tasted. Estimates of prevalence within the adult population vary from 1 in 500 for the more common types of synaesthesia (e.g. letter–colour synaesthesia or sound–sight synaesthesia, such as coloured hearing), to 1 in 25 000 for rarer forms (e.g. sound–odour or taste–smell synaesthesia).

Synaesthesia is **not** a disorder, as it rarely causes distress or interferes with daily life. Many synaesthetes do not even realise that they are unusual.

Synaesthesia is not imagined or learned, but an actual physical experience of the brain. Brain imaging studies of a group of synaesthetes showed that when they listened to words their **visual cortex** lit up in addition to the brain area associated with hearing. Normal people only activated the **auditory area**. The nearness of the active visual area to the auditory cortex suggests that in these people the experience of vision may be due to a knock-on effect – the neurons in the auditory cortex excite their neighbours, creating the visual effects. Similar simultaneous activation of sensory areas has been observed within the brain scans of other forms of synaesthesia as well.

Synaesthesia provides a unique research opportunity in order to explore the processes involved in sensory perception. By looking at the way the synaesthetes' unusual experiences arise, we can find out more about how the brain integrates and processes incoming sensory information to create our conscious experience of the world.

The application and use of brain research methods

In order to explain how the nervous system develops and maintains itself and to determine the means to tackle a variety of neurological and psychiatric disorders, neuroscientists employ a variety of methods to try to understand the structure and functioning of the human brain through their research and clinical practice. The limitations of traditionally invasive approaches in human research have given way to the use of non-invasive methods such as brain imaging (CT/fMRI) and, more recently, **transcranial magnetic stimulation** (TMS).

Case studies

This method involves an in-depth, intensive study of an individual, group, phenomena or situation – a 'spotlight on one instance', i.e. the particular and not the general. **Case studies** pay attention to contextual information, studying phenomena in their 'natural' setting, allowing analysis of a limited number of events or conditions and their relationships. These observations often become the basis for generalised theoretical principles. For example: Phineas Gage (1848) – frontal lobe damage and N.G. – Sperry's (1968) split-brain patient.

Advantages

- Qualitative data and methods (including clinical notes, videos, interviews, etc.) are flexible and can provide a great amount of description and detail.
- Case studies give insight and knowledge of a general nature, analysis of which can either contradict, revise, extend or validate what is known from prior research, leading to a better understanding of complex issues.
- Probing cognitive skills in a careful manner can supply data about dissociations between preserved and impaired brain functions, statistical analysis of which may highlight the function of the damaged region.
- A case study allows for longitudinal study of the case over time.

Ethical issues

- Clinical cases involving brain damage provide opportunities that researchers could not otherwise have as it would be unethical to create such damage just for research purposes. Much of what we know

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about the human brain comes from case studies of people who have had surgery or accidents.
- Confidentiality/anonymity is not always preserved.

Limitations
- For qualitative data and method:
  - procedure is not uniform for all cases and does not feature careful controls
  - there is no standard format for writing up case studies
  - the analysis of data is difficult due to its qualitative nature, especially if there is no baseline for comparison
  - it is open to experimenter bias. Accounts can be partial and restricted to descriptive data of interest to the researcher.
- Poor representativeness and ability to generalise.
- In clinical cases, the extent of the brain damage is not controllable or clearly localised to a specific area, causing a lack of precision in the results.
- Such findings do not permit the researcher to identify any specific causal associations.
- Case studies are useful only as an exploratory tool.

Brain stimulation

Direct brain stimulation
This method involves the application of a weak electrical current, usually in the form of a series of short pulses that mimic neural impulses, via tiny electrodes implanted into a specific locale in the brain.

In animals, electrical stimulation of parts of the brain often produces clear behavioural changes. In humans, this technique was pioneered by Penfield and Jasper (1954), in which they stimulated various regions of the cortex in a conscious patient and noted down the behavioural or sensory effects.

Alternately, chemicals that mimic neurotransmitters may be introduced directly into the brain via a small tube.

Advantages
- A way of investigating the function of living brain areas.
- Able to study localised motor and sensory functions.
- Able to highlight the function of inactivated regions.
- Previous functioning level known.
- Does not harm the brain.

Limitations
- Invasive – requiring either surgery and/or injections into the brain as a part of the process.
- Research based only on clinical patients. No healthy controls for comparison.
- Crude – not easy to tell how far the stimulation has spread.
- Results are inconsistent for higher functioning.
- Individual differences in behaviour.

Transcranial magnetic stimulation (TMS)
This technique applies a powerful magnetic field held close to the head which can briefly and focally disrupt neural activity in surface regions of cortex in order to stimulate or inhibit ('switch off') activity in precise areas of the brain.

The magnetic fields used in TMS are produced by passing current through a hand-held coil driven by a machine which switches the large current necessary in a very precise and controlled way. The coil is held on the scalp – no actual contact is necessary – and the magnetic field passes through the skull and into the brain. Weak electrical currents are induced to excite neurons in the brain by rapidly changing magnetic fields (electromagnetic induction). This way, brain activity can be triggered with minimal discomfort, and the functionality of the circuitry and connectivity of the brain can be studied.

Advantages
- A way of investigating the function of living brain areas.
- Non-invasive.
- Apparently free of harmful side-effects.
- Capable of modifying the activity of specific brain areas to:
  - highlight the function of inactivated regions

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  - demonstrate causal role of brain regions in the performance of specific tasks.
- Able to influence many brain functions, including movement, visual perception, memory, reaction time, speech and mood.
- Effects are temporary.
- Used for research with healthy and clinical subjects.
- Clinical/treatment applications.
- Relatively inexpensive.
- Previous functioning level known.

Limitations
- As it induces an electrical current in the human brain, TMS can produce a seizure. The risk is very low with TMS except in patients with epilepsy and patients on medication.
- There is some discomfort or pain from the stimulation of the scalp and associated nerves and muscles on the overlying skin.
- Poor localisation (1–5 cm), does not reach far below scalp, very poor spatial resolution.
- Hard to control target site (typically hand-held).
- Cannot be used near other scanners.
- Individual differences in behaviour.

Brain recording and imaging techniques

Electroencephalograph (EEG)
This technique was invented by Berger (1929). Because neurons use electricity to communicate, the EEG measures electrical activity in localised areas of the brain. A series of electrodes are attached to the surface of the scalp, and the activity of hundreds of thousands of neurons in the vicinity of each electrode is recorded, amplified and transferred to paper as wavelike patterns.

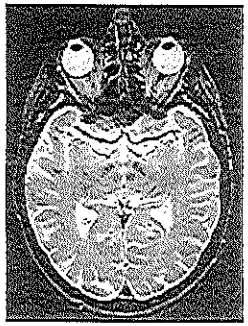
EEG tracings

Changes in electrical activity are particularly evident in behavioural states such as sleep, wakefulness and arousal, and abnormal electrical activity can signal disease states such as epilepsy and coma.

Advantages
- Non-invasive.
- General measure of brain activity.
- Can differentiate between different neurological conditions or behavioural states.
- Inexpensive and safe.
- Used for research with healthy and clinical participants.

Limitations
- Time-consuming.
- A general measure of activity.
- Averaging the activity from millions of neurons cannot establish precise activity in a particular, localised region.
- Signals measured are recorded on the scalp, which may not represent the activity in the underlying cortex.
- Only maps the surface of the cortex.
- Not an imaging technique.
- Chaotic and unpredictable.

Computerised tomography (CT)
This technique is also known as computerised axial tomography or CAT scan. A series of X-rays are sent through a patient's head at different angles, producing information that a computer then builds into detailed cross-sectional images (or slices) that show the structure of the brain, but not its function.



CT scan of brain

These scans reveal soft tissues more clearly than normal X-ray pictures, and are used mainly to diagnose neurological conditions such as tumours, blood clots, degenerative disease and the location of strokes. Adjacent slices can be combined to form a 3D representation and views along different planes.

Advantages
- Non-invasive.
- Provides detailed structural images of the living brain.
- Used for research with healthy and clinical participants.
- Abnormal neuroanatomy can be detected – soft tissues, including tumours, revealed more clearly than normal X-rays.
- Adjacent slices can be combined to form a 3D representation and views along different planes.

Limitations
- Only provides horizontal pictures.
- No information regarding function.
- Poor localisation.
- Expensive, and needs highly trained staff.

Single photon emission computed tomography (SPECT)
The main aim of SPECT in brain imaging is to measure the regional cerebral blood flow by mapping the distribution of the injected radioisotopes in the brain. The radioactive chemical does not enter the brain itself but stays in the bloodstream, allowing examination of the brain's blood supply, which is normally reduced to damaged areas.

The radiotracer (or radiopharmaceutical) used in SPECT emits gamma rays, which are detected by the gamma camera. Colour-coding of the image correlates with the amount of blood flow to areas of the brain as an indicator of differing levels of activity. The gamma camera can be used in planar imaging to acquire two-dimensional images or, by rotating the camera around the head, a three dimensional image of the distribution of the radiotracer can be obtained.

The radioisotopes used in SPECT have relatively long half-lives (a few hours to a few days) and are easy to produce as they do not require a dedicated cyclotron for their production (making it significantly cheaper than the PET). However, SPECT lacks good spatial or temporal resolution, and there are safety aspects concerning the administration of radioisotopes to the subject, especially for serial studies.

Advantages
- Provides an image of brain activity, and very detailed knowledge about function.
- Used for research with healthy and clinical participants.
- Provides 3D imaging of regional activity.
- Provides information about neuronal activity (blood flow).
- Less expensive than PET.

Limitations
- Mildly invasive because of the injection of radioisotopes (radioactive material).
- The use of radioactive agents means that only a limited number of scans can be performed on a single subject.
- Limited spatial resolution.
- Less sensitive than PET.
- Sedation may be necessary if the patient cannot lie still for the scan.

Positron emission tomography (PET)
With a PET scan, radioactive glucose (fluorodeoxyglucose) or oxygen compounds are injected into the blood stream. (These compounds are used as the brain is the highest consumer of glucose and oxygen compared to the other organs in the body.) The PET scanner detects gamma rays (positrons) emitted as the most active neuronal sites metabolise more of the radioactive compounds, enabling a computer to construct a series of colour-coded, functional pictures showing the activity levels of slices through the brain during different tasks.

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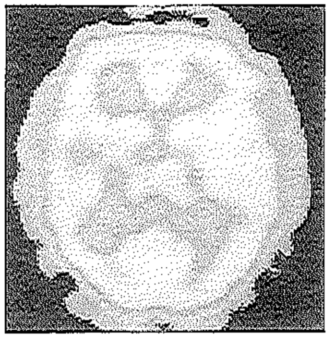


PET scan of brain

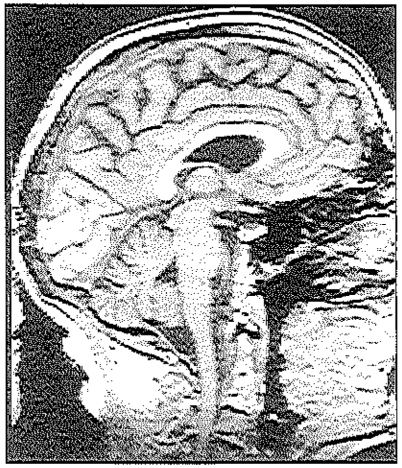
Different shades of colour correlate with differing levels of brain activity and are used to visually highlight even the most subtle disturbances in the expected levels of brain metabolism for a given person (according to comparisons with controls matched for age, gender, etc.).

Adjacent slices can be combined to form 3D images that reveal blood flow, as well as the metabolic and chemical activity of brain tissue.

Advantages
- Provides an image of brain activity and very detailed knowledge about function.
- Used for research with healthy and clinical participants.
- Provides 3D imaging of regional activity.
- Sensitive – can potentially image the whole brain, including deep and superficial brain structures.
- Moderate to high spatial resolution/clarity.
- Provides information about neuronal activity (blood flow, metabolic studies) and receptor mapping.
- Can trace any molecule with a radioisotope marker – psychopharmacological applications.
- Better spatial resolution and greater sensitivity than SPECT.

Limitations
- Mildly invasive because of the injection of radioisotopes (radioactive material).
- The use of radioactive agents means that only a limited number of scans can be performed on a single patient.
- Often small participant numbers used in studies. Because of averaging across multiple individuals, anatomical variation is not taken into account.
- Images do not provide clear structural information.
- Very poor temporal resolution (1–5 minutes).
- Very expensive (requires on-site cyclotron, and highly trained radiography staff).
- Sedation may be necessary if the patient cannot lie still for the scan.

Magnetic resonance imaging (MRI)
The patient is surrounded by a large electromagnet and exposed to short, powerful bursts of strong magnetic fields. These stimulate protons in the brain's tissue to emit radio signals, which are then detected and analysed by a computer to form an anatomical image of a 'slice' of the patient's brain.



MRI of brain

The MRI is especially useful in studying the brain and spinal cord as it provides greater contrast between normal and abnormal tissue, and between white and grey matter. Unlike the CT scanner, MRI scans can produce sagittal (side profile) and frontal images.

Advantages

- Provides very detailed knowledge about structure.
- 3D imaging – provides detailed view of the brain in different dimensions.
- Used for research with healthy and clinical participants.
- Safe, painless and non-invasive because:
  - it prevents the need for exploratory surgery
  - no X-rays or radioactive material are used
  - no special preparation (except the removal of all metal objects) is required from the patient. Patients can eat or drink anything before the procedure.

Limitations

- Very expensive.
- Susceptible to artefacts (ghosting) from movement, head placement and cavities, and transient scanner effects.
- Cannot be used with patients who are uncooperative as they must lie still. Sedation may be necessary if the patient cannot lie still for the scan.
- Cannot be used with patients who are claustrophobic (afraid of confined spaces) or who do not like loud noise.
- No ferromagnetic materials allowed – cannot be used on patients with metallic devices, like pacemakers.

Functional magnetic resonance imaging (fMRI)

Developed in the early 1990s as an application of the MRI, fMRI is able to detect brain function rather than solely brain structure, as with the MRI.

During an fMRI experiment, subjects are required to carry out a cognitive task, consisting of periods of activity and periods of rest, while their brain is scanned repeatedly. During the activity, the magnetic resonance signal from the region of the brain involved in the task normally increases due to the flow of oxygenated blood to that region. Signal processing is then used to provide both an anatomical and a functional view of these regions.

The fMRI is often used prior to brain surgery, enabling neurosurgeons to locate the desired region and to map the locus of critical brain functions.

Advantages

- High quality anatomical images can be obtained in the same session as the functional studies, giving greater confidence as to the source of the activation.
- Excellent spatial resolution of neural activity (1–2 mm).
- Provides 3D imaging.
- Capable of making dynamic images of the brain as opposed to the static images of other mapping methods.
- Used for research with healthy and clinical participants.
- Non-invasive and non-toxic as it does not require injection with any contrasting agents or radioactive isotopes, and so is considerably safer than PET.
- More widely available and cheaper than PET.
- fMRI images can detect a stroke at a very early stage, can monitor the growth and function of brain tumours and enable the detection of abnormalities that might be obscured by bone tissue with other imaging methods.
- It is also possible to carry out spectroscopy, which is chemically specific, and can assist in the study of metabolic processes in the brain.

Limitations

- Hard to compare across subjects because of blood flow variances.
- As it is based on blood flow, it is not yet possible to directly map neuroreceptors as PET scans can.
- The technique is very expensive, especially because of the shielding required.
- Not subject-friendly because:
  - it is claustrophobic, loud
  - no ferromagnetic materials are allowed
  - it excludes patients with pacemakers or implants.
- fMRI is limited to activation studies.
- Poor temporal resolution (250 ms = 4 images/second).
- Susceptible to artefacts (ghosting) from movement, head placement, cavities, and transient scanner effects.
- The images also appear about 5–8 seconds behind real-time changes.
- Sedation may be necessary if the patient cannot lie still for the scan.

Comparison of PET, SPECT and fMRI scans

<table>
<tr><th>Positron Emission Tomography (PET scan)</th><th>Single Photon Emission Computed Tomography (SPECT scan)</th><th>functional Magnetic Resonance Imaging (fMRI)</th></tr>
<tr><td colspan="3">• Provides images of a functioning brain at work.
• Can also represent the active areas of the brain on a 3D image.</td></tr>
<tr><td>• Detects the uptake of radioactive glucose within the functioning areas of the brain.</td><td colspan="2">• Detects changes in blood-flow to active brain areas.</td></tr>
<tr><td colspan="2">• Mildly invasive because of needing to inject radioactive material into the brain.
• Cannot provide detailed images of brain structure – needs to be superimposed over corresponding CT or MRI.</td><td>• No radioactive material required.
• Not an invasive procedure.
• Can also provide detailed images of brain structure.</td></tr>
</table>

Glossary of terms

Alpha waves
The medium-amplitude, relatively high-frequency brainwave pattern prominent in an awake, relaxed adult whose eyes are closed. These brainwaves are also present when meditating or in a state of deep relaxation.

Altered state of consciousness (ASC)
Any state other than ordinary/normal waking consciousness; characterised by perceptual and cognitive distortions, disturbed sense of time, heightened or suppressed emotions, increased or decreased physiological changes and changes in self-control.

Amplitude
The height, or size, of the peaks and troughs indicating the level of voltage within the electrical impulses.

Analytical functions
Cognitive operations, mainly located in the left hemisphere, involving logical reasoning to analyse, organise and interpret information, including mathematical and scientific activities.

Aphasia
A disorder, brought about by brain damage, involving the loss of an individual's ability to produce or recognise language.

Arousal
Activation of bodily resources leading to a heightened state of physical alertness and readiness for action.

Association areas
Regions of the cerebral cortex which process and integrate sensory information, relating it with higher mental abilities.

Attention
The process whereby we selectively focus on and respond to certain environmental stimuli while ignoring other simultaneous inputs.

Auditory area
The area of the temporal lobes which receives and processes signals/information detected by our sense of hearing.

Automatic processes
Those actions which require little conscious effort and minimal attention, i.e. lower levels of awareness. They may be performed unconsciously and/or at the same time as other activities. These are usually well-rehearsed.

Autonomic nervous system (ANS)
The branch of the PNS which is divided into the sympathetic and parasympathetic nervous systems. Both systems work to expend and conserve the energy of glands, nerves and smooth internal (non-skeletal) muscles controlling involuntary responses associated with organs and blood vessels.

Awareness
A subjective condition of knowing something, from internal states or feelings to external, environmental stimuli.

Beta waves
The low-amplitude, high-frequency brainwave pattern of a normal, awake, alert person.

Brain stimulation
A method of investigating the function of living brain areas involving the application of either a weak electrical current, usually in the form of a series of short pulses that imitate neural impulses, or the introduction of chemicals that mimic neurotransmitters into a specific locale in the brain, in order to produce clear behavioural changes in the subjects.

Brainwaves
The electrical discharges of the living brain as recorded by an electroencephalograph (EEG). Brainwaves are measured and described in terms of their amplitude (voltage) and their frequency (cycles per second).

Broca's aphasia
Language impairment caused by damage to Broca's area, characterised by the inability to produce clear, grammatical speech.

Broca's area
A specialised area in the left frontal lobe that is responsible for controlling muscles enabling the ability to use language, encompassing speaking and writing.

Case studies
A research method involving an in-depth, intensive study or account of an individual, group, phenomena or situation within its real-life context. In brain research, this usually involves an individual, brain-damaged patient.

Central nervous system (CNS)
Major subdivision of the human nervous system that includes the brain and the spinal cord.

Cerebellum
An area at the rear base of the brain responsible for controlling muscle tone, balance (including posture) and the coordination of skilled movements.

Cerebral cortex
Layer of tissue that constitutes the wrinkled (convoluted) outer layer of the cerebrum, which enables conscious experience and higher mental functioning, as well as basic sensory and motor functioning.

Cerebral hemispheres
The left and right halves of the cerebral cortex (separated from the front to the back of the brain by the longitudinal fissure, but connected by the corpus callosum).

Change blindness
A phenomenon in visual perception in which very large changes occurring in full view within a visual scene are not detected by the observer.

Cognitive functions
Processes that involve mental activity in order to process information, such as thinking, reasoning, planning, learning, memory, perception, using language, etc.

Computerised tomography (CT or CAT scan)
For brain research, information from X-rays sent through a patient's head at different angles are analysed by a computer to create detailed cross-sectional images (or slices) providing structural information that reveals soft tissue, especially damaged or abnormal brain areas.

Consciousness
An individual's awareness of their mental activity, including their thoughts, sensations and feelings.

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Content limitations
Our ability to control the substance of what is contained within our thoughts. In normal waking consciousness, we can focus on items in a logical manner, whereas in altered states of consciousness other material may enter our thoughts in a disorganised or illogical fashion.

Controlled processes
Procedures needing higher levels of awareness, i.e. requiring an ability to focus our attention and concentrate.

Corpus callosum
A large mass of neural fibres connecting the left and right hemispheres of the cerebrum, allowing them to communicate with one another.

Cortical lobes
Divisions of the cerebral cortex that assist in identifying the areas in which specific sensory, motor and associative functions are located.

Daydream
An altered state of consciousness involving a shift of an individual's attention away from external stimuli to self-generated thoughts and images.

Delayed sleep phase syndrome (DSPS)
A condition which involves an inability to reset the sleep/wake cycle in response to environmental time cues, resulting in a misalignment of the timing of sleep, peak period of alertness, core body temperature, hormonal and other daily rhythms relative to societal norms.

Delta waves
Large, slow brainwaves that occur in deeper sleep (NREM stages 3 and 4).

Dreams (night dreams)
The mental activity that takes place during sleep, particularly during REM sleep. During dreams, there is increased electrical activity in the brain, along with increases in blood flow and brain temperature.

Dualism/Dualist
The philosophy proposed by Descartes which assumes that our consciousness is divided according to physical and ethereal/spiritual terms, that is body versus mind (or soul).

Electrical stimulation of the brain (ESB)
A research method used to explore the function of various brain areas involving the insertion of a microelectrode into the brain which delivers a mild electrical current in order to 'activate' the neurons in a particular site.

Electrocardiogram (ECG)
A device used to detect, amplify and record the difference in electrical potential generated by the heartbeat and representing it in graphic form. This can be used to provide a measure of different states of consciousness, as autonomic arousal is often lowered within these states.

Electroencephalograph (EEG)
A device using surface electrodes attached to the scalp to detect and amplify the electrical impulses produced by neurons activated within the brain which are then transferred to paper and recorded as wavelike patterns, thereby providing an indication of relative levels of activity of regions within the brain. Used in sleep laboratories to monitor an individual's progression through the various stages/levels of sleep.

Electromyograph (EMG)
A device used in sleep laboratories which detects, amplifies and records electrical activity within the muscles in order to measures muscle tension. Muscle tension is lax during REM sleep.

Electro-oculargram (EOG)
A device used in sleep laboratories that uses electrodes attached to the face, which detects, amplifies and records electrical activity within the muscles surrounding the eyes in order to measure eye movements. This enables us to determine whether an individual is engaged in REM or NREM sleep.

Fight-or-flight response
Triggered by the hypothalamus, a state of increased arousal that occurs when the sympathetic division of the ANS is activated which prepares or mobilises the body to confront a 'threatening' situation or 'fight' it or, alternatively, flee to safety from a situation, hence the term 'flight'.

Frequency
The number of brainwaves per second.

Frontal lobe
Areas located at the top front of the cerebral cortex that enable higher mental functioning involving learning, memory, control over movement and speech, as well as the processing of smell. The frontal lobes also control emotions, personality and intellectual tasks requiring reasoning and planning.

Functional magnetic resonance imaging (fMRI)
An application of the MRI, the fMRI is able to detect brain function by monitoring changes in blood flow and represent this within a detailed 3D image.

Functional neuroimaging
Methods for scanning the brain, such as PET and fMRI scans, that provide images of the brain 'at work'.

Galvanic skin response (GSR)
A measure of the electrical conductivity of the skin used as an indicator of the activity of the sweat glands and thereby gauge an individual's level of arousal. Increased activity of the sweat glands leads to higher electrical conductivity (or, conversely, lower resistance) of the skin. Altered states of consciousness may lead to alterations in the levels of autonomic arousal, with corresponding variation in the GSR.

Gamma rays
Electromagnetic radiation with an extremely short wavelength that is emitted during radioactive decay.

Hemispheric specialisation (also known as brain lateralisation)
Particular abilities and functions are located in each of the cerebral hemispheres rather than equally in both.

Hypnic jerk
A reflex muscle twitch throughout the body that occurs when an individual is falling asleep (NREM stage 1).

Hypnogogic state
Fanciful, dreamlike, vivid mental images which may occur just as an individual enters NREM stage 1 sleep.

Imaging techniques
A general term used to refer to the various methods used to study the brain that provide actual images of the living brain in terms of its structure and/or function.

Intact brain
A healthy, undamaged, 'normal' brain.

Invasive techniques
Brain research techniques that involve opening up and/or putting something into the brain itself (e.g. injection, electrodes, etc.).

K complex
A characteristic within NREM stage 2 brainwave patterns indicated by a spike of activity which is of a much higher amplitude than the surrounding pattern.

Lateralisation
The specialisation of functions within the two cerebral hemispheres. The more lateralised an individual is for a particular ability, the more this function will be centred in only one area or hemisphere of the brain.

Left hemisphere
The left half of the cerebrum controls verbal/linguistic functions (including speech and writing) and analytical/logical functions, processing information in a sequential manner.

Lobes
The four divisions of the cerebral cortex that assist in identifying the areas in which specific sensory, motor and associative functions are located.

Magnetic resonance imaging (MRI)
Protons in the patient's tissues are stimulated by a large electromagnet causing them to vibrate and emit radio signals which are then detected and analysed by a computer to form an image of a 'slice' of the patient. The MRI is especially useful in studying the brain and spinal cord as white and grey matter, along with normal and abnormal tissue, are distinct and well defined in MRI scans.

Meditation
A procedure which employs mental exercises to achieve a highly focused state of consciousness.

Microsleep
A short period of drowsiness or sleeping which intrudes into the waking state; usually an effect of sleep deprivation.

Motion after-effect
A visual illusion experienced after watching a moving visual stimulus with stationary eyes for an extended period resulting in a stationary stimulus appearing to move in the opposite direction.

Motor cortex
The area within the frontal lobes of the cerebral hemispheres that directs the control of the body's voluntary muscles, enabling fine, coordinated movement.

Motor neurons/Motor (efferent) nerves
Specialised neurons within the PNS that transmit information or commands from the brain via the spinal cord to the muscles, glands or organs to enable a response.

Neuroimaging
Brain scanning techniques (includes CT, PET, SPECT, MRI and fMRI scans) that produce detailed images of the brain.

Neurons
The basic 'building blocks' of the brain and nervous system, individual nerve cells are specialised to receive input from other nerve cells, process and/or transmit information to other cells via electrochemical impulses.

Neuropsychology
Branch of psychology specialising in the assessment and diagnosis of brain injury and how this affects cognitive abilities and behaviour.

Neurotransmitter
A chemical which alters the electrical activity in other neurons after they are released into the synaptic cleft and attach to receptor sites on the soma or dendrites of the next neuron.

Non-invasive techniques
Brain research techniques that do not involve opening up and/or entering the brain with an instrument.

Non-skeletal muscles
Muscles that are associated with internal organs, such as the heart and lungs, as well as the glands.

Non-verbal functions
Cognitive operations, mainly located in the right hemisphere, that focus on holistic perception, including recognition of faces/patterns, spatial skills, visualisation and manipulation, as well as our ability to appreciate and create art and music.

Normal waking consciousness (NWC, also known as ordinary waking consciousness)
A state where an individual is aware of their thoughts and feelings and of sensations they are experiencing from the environment. Attention is focused and the individual has a sense of time.

NREM (non-REM) sleep
Stages of sleep not associated with rapid eye movements which contain little dreaming, and during which an individual is able to move.

Occipital lobe
The lower rear part of the brain which processes visual information enabling interpretation and perception.

Parasympathetic nervous system
The branch of the autonomic nervous system involved in monitoring the routine operation of the body's internal functions that promote growth and regeneration along with conserving bodily functions after a state of arousal to enable individuals to relax, restore body energy and return to a homeostatic state.

Parietal lobe
Areas located at the top of the brain, behind the frontal lobes and central fissure, which mediate attention to register and process bodily (somatic) sensations such as touch, temperature, pressure, pain and body movement.

Perception
The physiological and psychological process of selecting,

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organising and interpreting sensory information to form a unique, cognitive understanding of our environment.

Perceptual anomaly
Where the objective reality of an existing physical stimulus is inconsistent with an individual's subjective perception.

Perceptual distortions
A feature of altered states of consciousness whereby sensations and emotions are either experienced as stronger and more vivid or are suppressed and blurred. There can also be hallucinations or a detachment from our sense of 'self', becoming unclear about where we end and our environment begins.

Peripheral nervous system (PNS)
The network of nerves that branch out from the CNS to all other parts of the body, the PNS delivers information from the sensory receptors, via afferent nerves, to the CNS, and transmits messages from the CNS to muscular or glandular effector organs via efferent nerves. The PNS is divided into two subsystems: the somatic nervous system and the autonomic nervous system.

Physiological responses
Identifiable biological behaviours involving physical changes within the body, such as glandular activity or muscular action, due to an external stimulus.

Positron emission tomography (PET scan)
PET scans detect gamma rays emitted as radioactive glucose or oxygen compounds injected into the patient are metabolised within the brain, thereby providing functional information by identifying neuronal sites that are active during different cognitive or behavioural activities.

Primary auditory cortex
Region in each of the temporal lobes involved with hearing and the interpretation of sounds from both ears.

Primary motor cortex
A strip at the rear of each frontal lobe that is involved in the planning and control of voluntary body movement.

Primary somatosensory cortex
A strip at the front of each parietal lobe that receives tactile sensory information from various receptor cells in the skin and skeletal muscles, enabling perception of bodily sensations.

Primary visual cortex
The area within the occipital lobes where information from our retinas is processed to enable visual perception.

REM (rapid eye movement) sleep
A stage during the sleep cycle in which electrical brain activity is characterised by erratic, low voltage patterns similar to those observed during the waking state. During this stage, there are bursts of rapid eye movements and the body is relaxed to the point of paralysis. It is during this stage of sleep that most dreaming occurs.

REM rebound
The phenomenon where individuals will spend more time than usual in REM sleep subsequent to being selectively deprived of REM sleep.

Restorative theory of sleep
This theory proposes that the purpose of sleep is to allow the body and nervous system to grow and repair any damage that may have occurred to tissues during the day.

Reticular activating system (RAS)
A structure in the brainstem that is responsible for sustaining consciousness, controlling sleep and wakefulness, directing attention to sensory stimuli, and mediating various levels of alertness and general arousal mechanisms.

Right hemisphere
The right half of the cerebrum controlling non-verbal, spatial functions and processing information in a holistic manner.

Self-control
Our ability to knowingly and voluntarily direct our own actions. In altered states of consciousness, we become more susceptible to suggestion and our actions can be influenced or dictated by others.

Sensation
The reception or gathering of environmental energy, its transduction, and its transmission to the brain. It is a physiological process which is similar for all individuals with normal sensory ability.

Sensory neurons/Sensory (afferent) nerves
Specialised neurons within the PNS that detect sensory information received from receptors all over the body and transmit this to the brain via the spinal cord.

Single photon emission computed tomography (SPECT scan)
A diagnostic scan that detects gamma rays emitted from a small, safe amount of a radioactive drug to measure blood flow inside the brain, thereby providing functional information about regions that are active during different cognitive or behavioural activities.

Skeletal muscles
Muscles that are attached to the skeleton which enable us to produce voluntary movement.

Sleep
An altered state of consciousness marked by reduced metabolism and lowered consciousness. Sleep consists of different stages, each of which can be distinguished by characteristic physiological responses including brainwave patterns, presence or absence of rapid eye movement, and changes in heart rate, breathing rate, body temperature and muscle tone.

Sleep deprivation
A lack of sleep leading to lethargy, irritability, loss of concentration, REM rebound, headaches and difficulty completing low-level boring tasks.

Sleep spindles
Brief bursts of higher frequency activity occurring in stage 2 sleep, indicating that a person is asleep.

Somatic nervous system
The subdivision of the PNS that controls voluntary behaviour by connecting the CNS with sensory organs, skeletal muscles and glands.

Somatosensory cortex
The area at the front of the parietal lobes that receives and analyses sensory input from all parts of the body.

Spatial neglect
A disorder caused by damage to areas of the right parietal lobe typified by behaviours indicating the individual's inability to respond to the left half of their body and/or external environment.

Spinal cord
Part of the central nervous system relaying messages via nerve fibres to and from the brain.

Split brain
The condition after surgery is performed to cut the corpus callosum in order to treat some cases of severe epilepsy, which essentially results in the patient having two separate brains.

State of consciousness
An individual's level of mental awareness of sensations, perceptions, memories and feelings. An individual's state of consciousness can range from being fully awake and focused through to unconsciousness.

Streams of consciousness
A term introduced by William James to emphasise that consciousness is continuously changing, flowing series images, thoughts, sensations and feelings.

Stroke
Damage to part of the brain caused by interruption to its blood supply. Symptoms may include paralysis (especially on the side of the body opposite to the site of the stroke), aphasia (disturbance of language and speech), coma, convulsions and other neurological signs determined by the location of the stroke.

Structural neuroimaging
Methods for scanning the brain, such as CT and MRI scans, that provide images of brain areas and 'structures'.

Survival function of sleep (also known as evolutionary theory of sleep)
This theory proposes that sleep serves an adaptive function, enhancing an animal's chances of survival by making it inactive at the most dangerous times of the day and therefore less noticeable to predators. Also, diurnal animals, such as humans, often have poor night vision, and so would not be able to see many of the hazards present in the dark.

Sympathetic nervous system
The branch of the autonomic nervous system, triggered as a result of the 'fight-or-flight' response, which activates or inhibits bodily functions causing a state of arousal which mobilises the body's energy and resources to cope in an emergency or threatening situation.

Synaesthesia
Meaning 'joined sensation', a condition whereby some people experience a sensory blending or crossover as two or more senses are automatically and involuntarily coupled.

Temporal lobes
The areas on each side of the cerebral cortex (below the lateral fissure) where auditory (sound) information is projected, enabling hearing to register. In most people, the left temporal lobe contains Wernicke's area, a language centre where speaking, reading, writing and spelling are processed and understood. This lobe also acts as a centre for the recognition of different visual forms, enabling individuals to distinguish objects from one another, as well as memory (through the hippocampus).

Thalamus
A structure deep within the forebrain that receives and integrates sensory information (with the exception of smell), and relays this information to the appropriate part of the cerebral cortex for further processing.

Theta waves
The irregular brainwave pattern with a frequency in between alpha and delta waves and a mixture of high and lower amplitude. These brainwaves are characteristic of a person in light sleep (NREM stages 1 and 2).

Time orientation
The ability to perceive the passage of time. In normal waking consciousness, we experience the normal progression of time, and are aware of our context within past, present and future, whereas during altered states of consciousness we can experience a blurring of our perception, with time appearing slow down or speed up.

Transcranial magnetic stimulation (TMS)
The technique in which a powerful magnetic field is passed through the skull that can briefly and focally disrupt neural activity in surface regions of cortex in order to stimulate or inhibit activity in precise areas of the brain to measure their function.

Verbal functions
Cognitive operations, mainly located in the left hemisphere, that focus on our ability to speak, read, write and understand language.

Visual cortex
The area within the occipital lobes where information from the retina is processed to enable visual perception.

Wada test
A research procedure using participants with intact brains where one cerebral hemisphere is anaesthetised to determine which hemisphere controls the ability to speak.

Wernicke's aphasia
Language impairment caused by damage to Wernicke's area, characterised by the inability to understand spoken language.

Wernicke's area
A specialised area in the left temporal lobe that is responsible for the comprehension of the meaning of words.

> Definitions for the research terms associated with this unit can be found at the end of Chapter 3.

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Revision checklist – Mind, brain and body

Tick (✓) the box once you are confident that you have covered and understand each concept.

Consciousness	
Definition of consciousness	
The work of René Descartes	
The work of William James	
Normal waking consciousness versus altered states of consciousness	
Daydreaming	
Meditation	
Alcohol-induced state	
Levels of awareness	
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Physiological responses which can denote various states of consciousness	
Electrical activity of the brain	
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Sleep deprivation	
Sleep recovery patterns	
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Microsleeps	
Sleep/wake cycle shifts during adolescence	
Divisions of the nervous system	
Central nervous system (CNS)	
Peripheral nervous system (PNS)	
• Somatic nervous system	
• Autonomic nervous system (ANS)	
- The sympathetic division of the ANS	
- The parasympathetic division of the ANS	

The four lobes of the cerebral cortex	
Frontal lobe	
• Broca's area	
• Motor cortex	
Parietal lobe	
• Somatosensory cortex	
Occipital lobe	
• Primary visual cortex	
Temporal lobe	
• Wernicke's area	
• Primary auditory cortex	
Association areas	
Hemispheric specialisation	
The nonverbal cognitive and behavioural functions of the right cerebral hemisphere	
The verbal and analytical cognitive and behavioural functions of the left hemisphere	
The reticular activating system	
Thalamus	
Studies investigating the cognitive processes of the brain	
Broca's and Wernicke's aphasia	
Spatial neglect	
Split-brain studies	
• The work of Sperry and Gazzaniga	
Perceptual anomalies	
• Motion after-effect	
• Change blindness	
• Synaesthesia	
Brain research methods	
Case studies	
Direct brain stimulation	
Transcranial magnetic stimulation (TMS)	
Brain recording and imaging techniques	
• Electroencephalograph (EEG)	
• Computerised tomography (CT)	
• Positron emission tomography (PET)	
• Single photon emission computed tomography (SPECT)	
• Magnetic resonance imaging (MRI)	
• Functional magnetic resonance imaging (fMRI)	

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